

# Feasibility Studies on a Replacement Research Reactor Optimized for Cold Neutron Sources at NCNR

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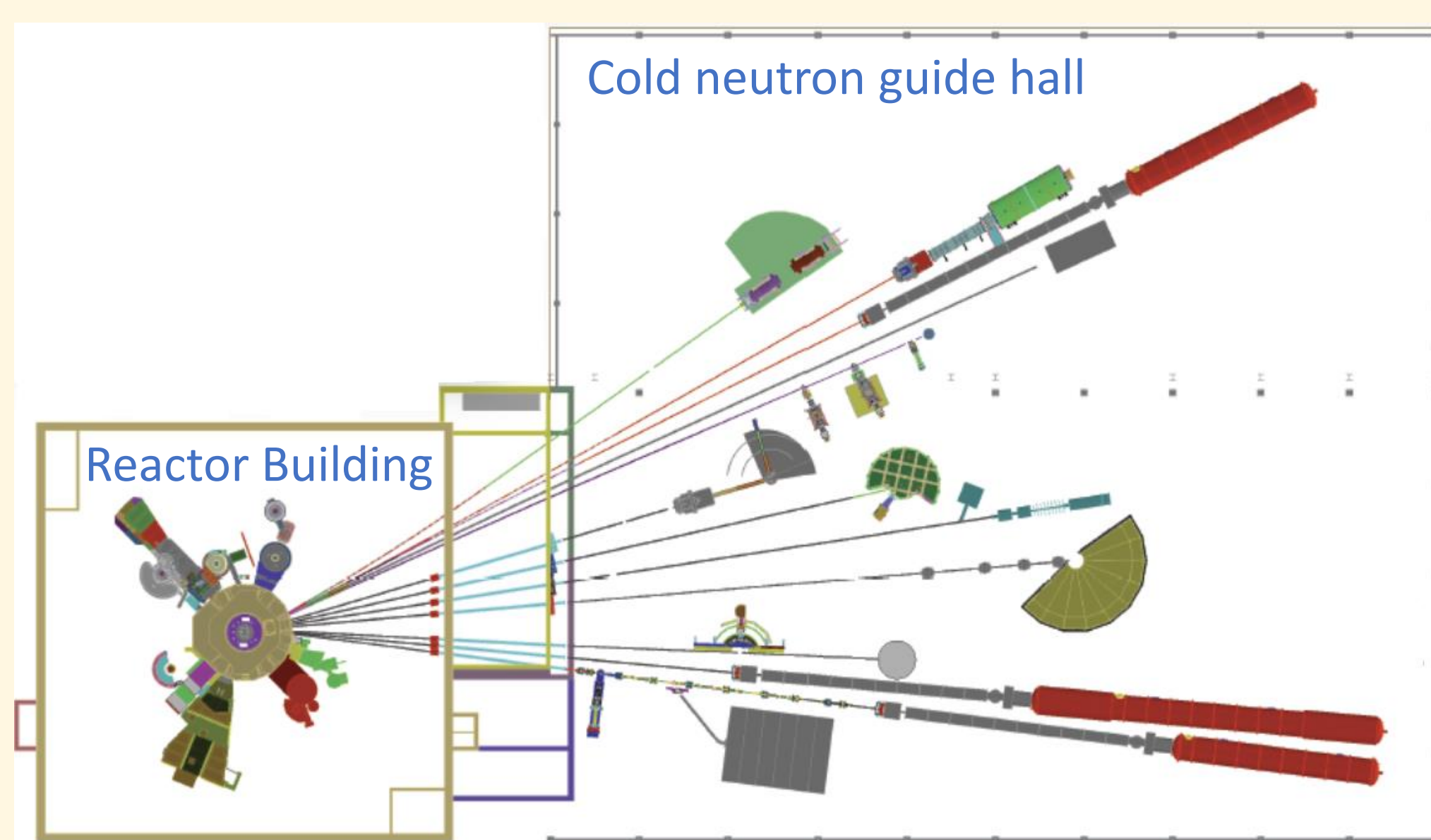
## BACKGROUND

### Neutrons at NIST

- The present 20 MW NBSR at NIST was built in the 1960s
- NBSR has evolved into one of the world's premier **neutron source** facilities hosting over 2,000 guest researchers annually
- Over the past 45 years, neutrons have been used to study the structure and dynamics of materials, as well as fundamental nuclear physics and analytical chemistry
- The emphasis has changed over the same period to the use of very low energy or **cold neutrons** to improve resolution and instrumentation, and to better probe the structure of larger molecular systems (**biological materials, polymers, aggregates**)

### The Life of Neutrons

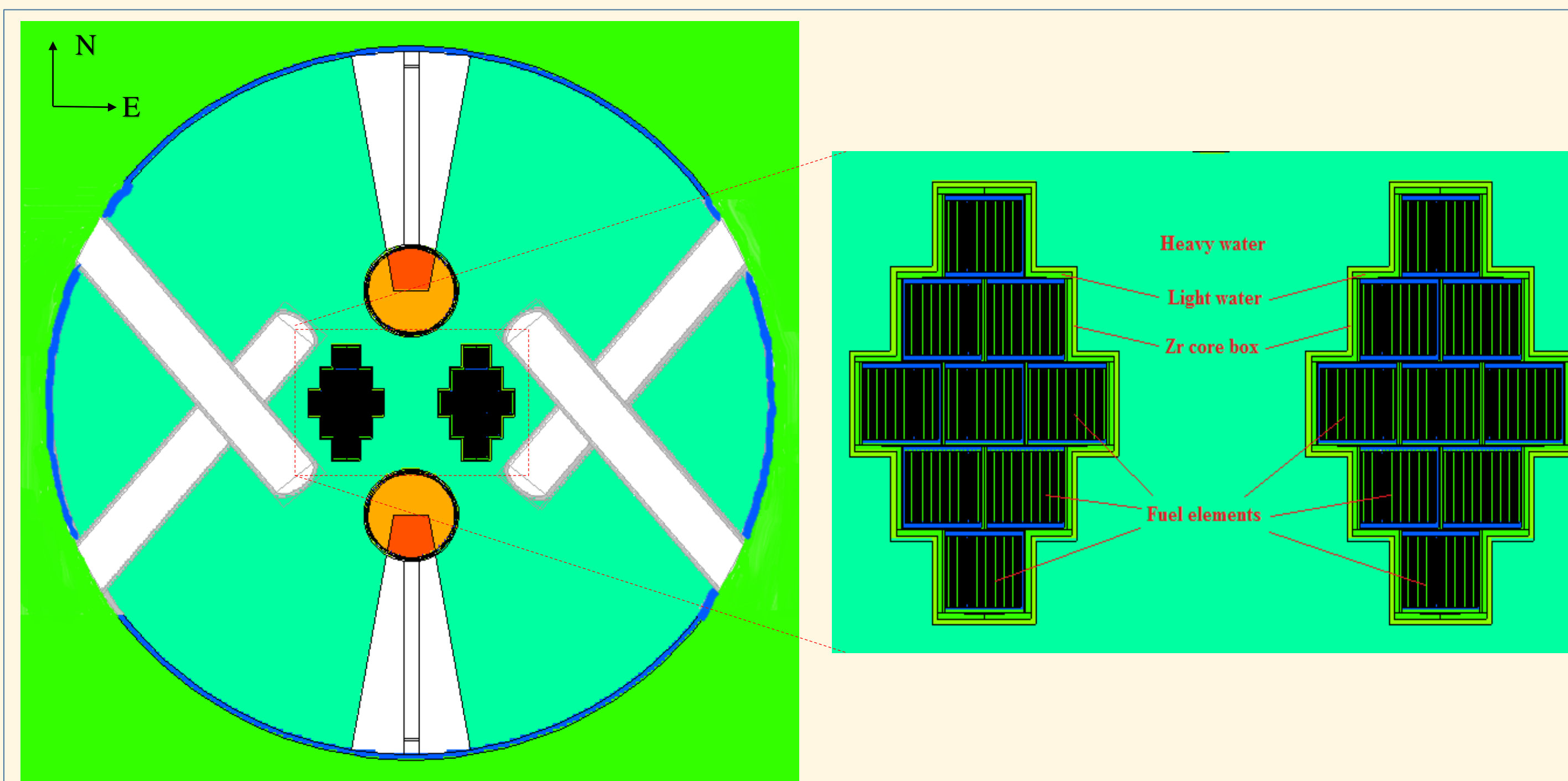
- Initial **fission neutrons** have average kinetic energy of 2 MeV
- Thermal neutrons** slowed down by **reactor moderator** have energy range (30-400 meV)
- Cold neutrons** further slowed down by **cold moderator** have energy less than 5 meV ( $\lambda > 4 \text{ \AA}$ ), equilibrium at  $T = 20 \text{ K}$
- Cold neutrons can be transported **tens of meters** in guides with very small losses



## REACTOR DESIGN

### Principles and Objectives

- Principle purpose is to optimize the production of high quality **cold neutrons**
- New design provides **two** independent cold neutron sources
- Combines state of the art **research reactor** design features

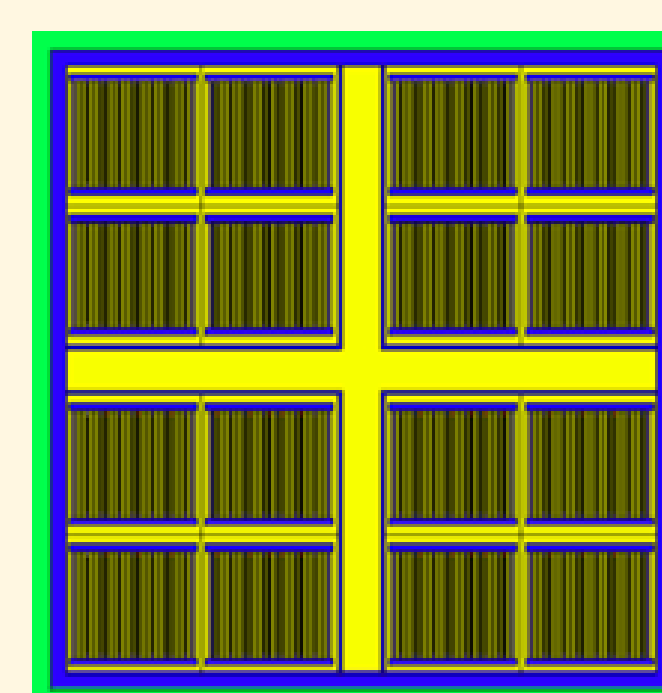


X-Y View at the Mid-plane of the reactor

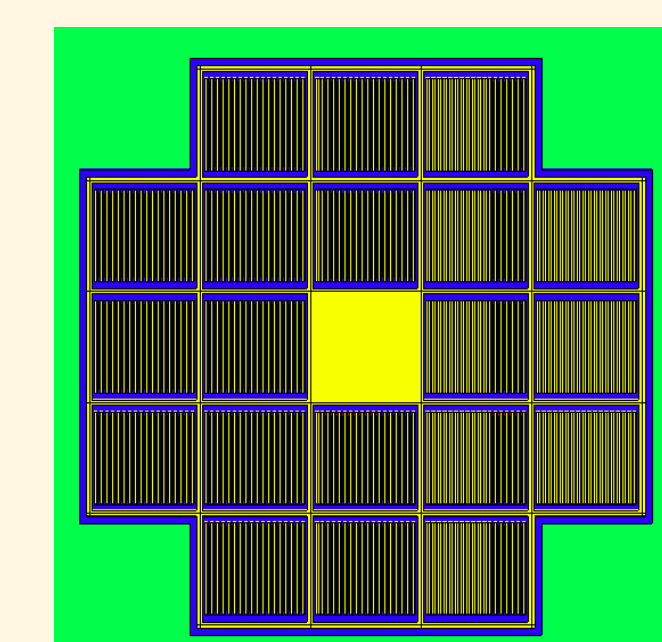
The core consists of total 18 fuel elements (FEs) that are evenly distributed into two horizontally split regions with the gap distance about 19.5 cm. Two vertical CNSs are placed at the north and south side of the core. Four thermal beam tubes are located at the east and west side of the core at different elevations.

### Key Design Parameters of the New Reactor

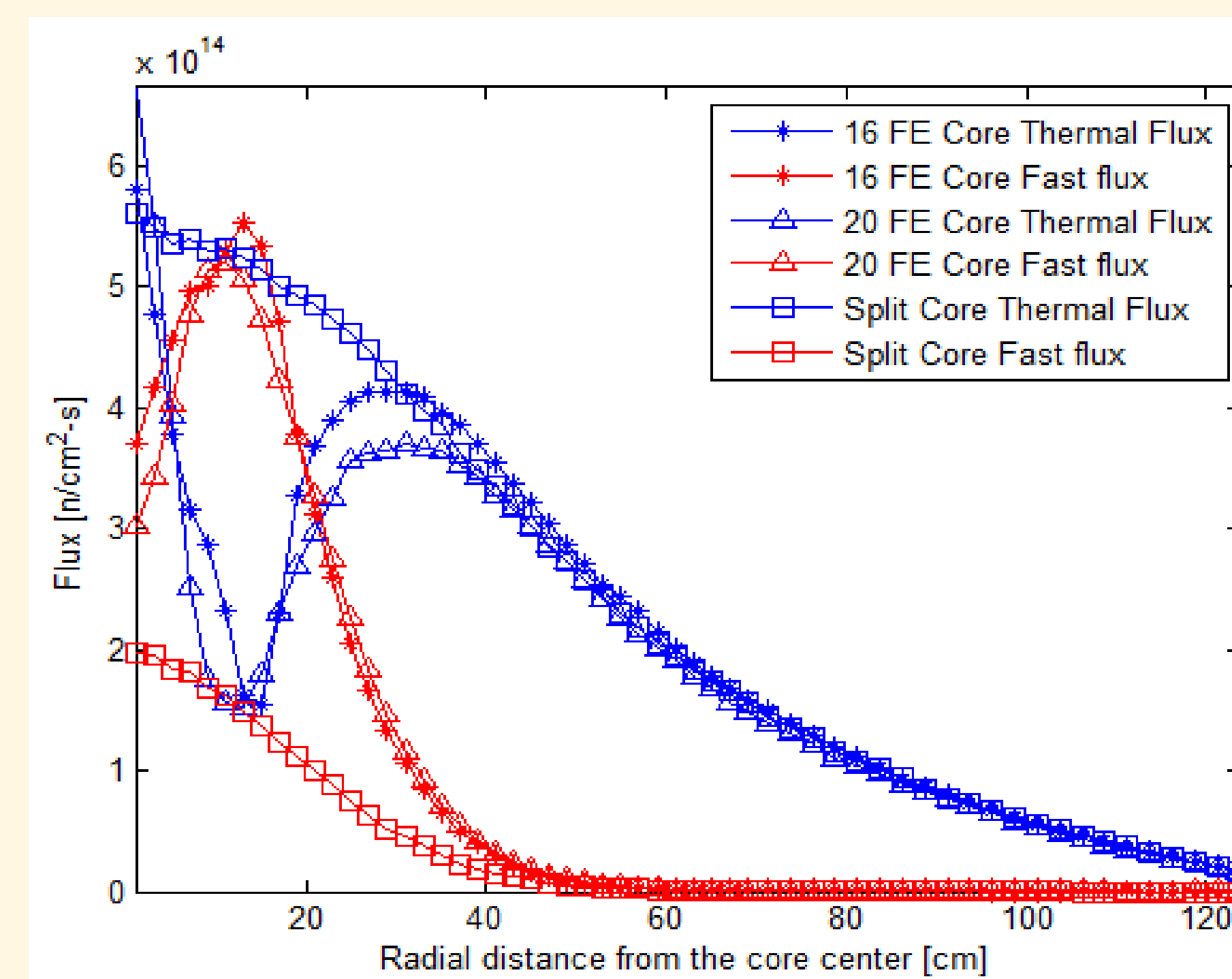
	New Reactor	NBSR
Reactor power (MW)	20 - 30	20
Fuel cycle length (days)	30	38.5
Fuel material	$\text{U}_3\text{Si}_2/\text{Al}$	$\text{U}_3\text{O}_8/\text{Al}$
Fuel enrichment (%)	19.75 (LEU)	93 (HEU)



16 FE Core (OPAL)

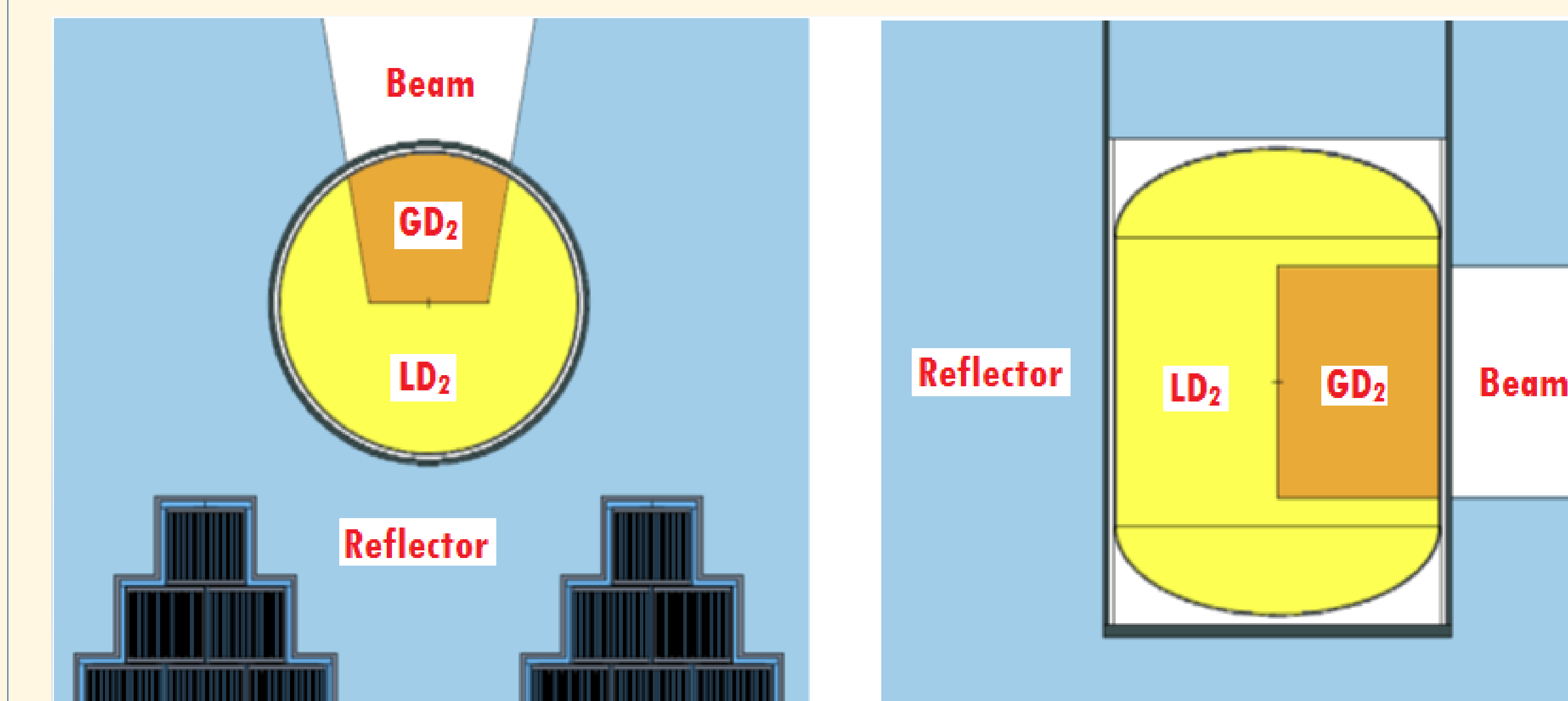


20 FE Core (CARR)



Unperturbed Radial Flux Behavior

## COLD NEUTRON SOURCE DESIGN

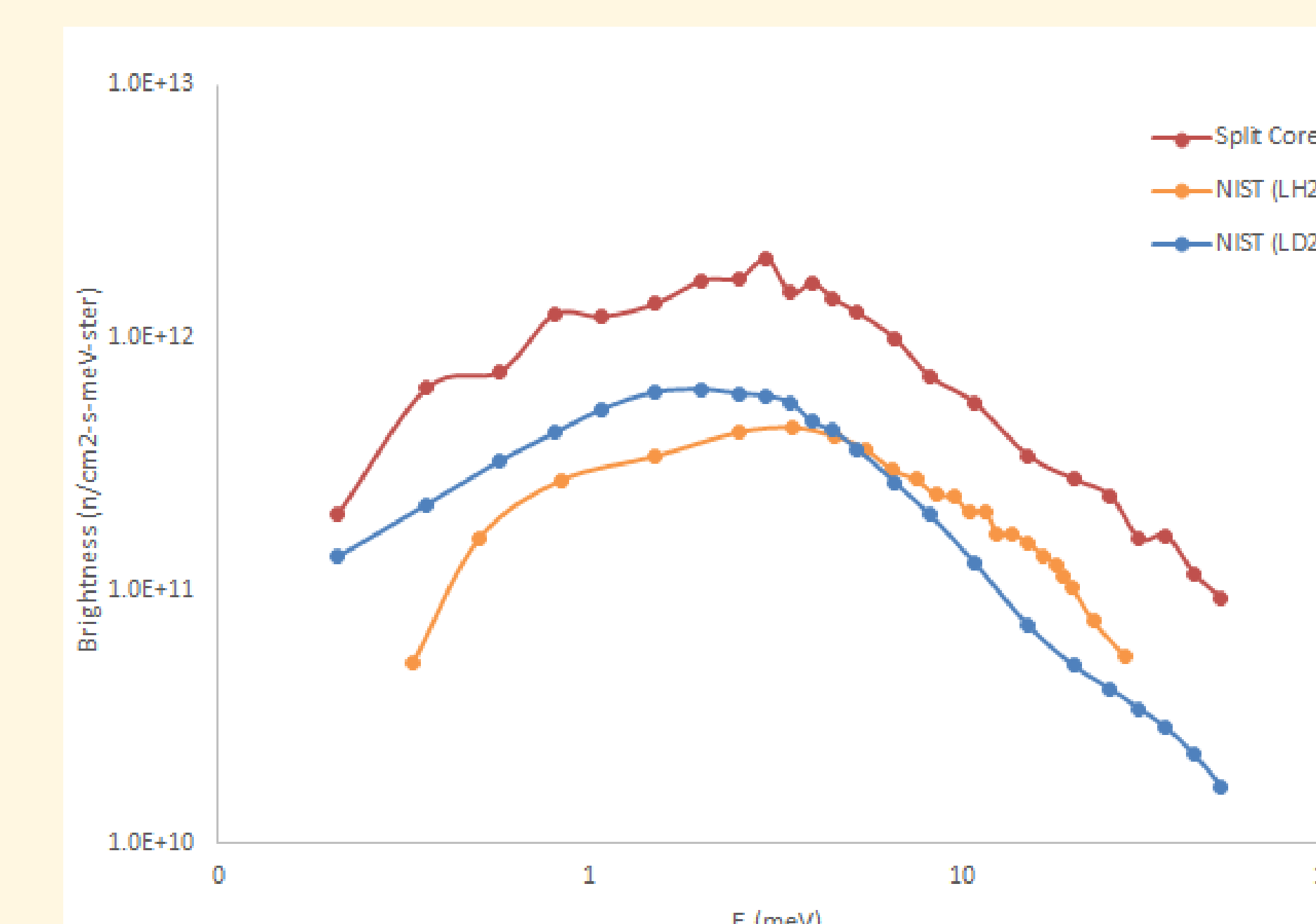


Top View

Side View

The distance from the center of CNS to the center of the reactor is 40 cm. The total volume of LD2 in one CNS is about 21 liter.

### Advances of the CNS in the split core



The Cold neutron source brightness in the split core is about 4 times that of the exiting source at NBSR with the same power

## SUMMARY

- Horizontally split core is our current focus and advantageous for beam tube reactors in terms of **signal to noise ratio**, **neutron performance**, etc.
- Cold neutron **spectrum brightness/MW** in the split core outperforms existing sources